lymph, both of human and bovine origin, was employed, but from variolous lymph as well." From these plates sub-cultures were obtained, and from the third and fourth generation typical vaccinia was induced both in calves and in children.

Monkeys have been of considerable assistance to Dr. Copeman in his investigations upon lymph. He began by proving experimentally that they are susceptible both to vaccination and to variolation, and he found that in them vaccinia protected from small-pox, and *vice versa*. "In no instance had the experiment a fatal termination," nor does it appear from the report that even variolation caused serious illness; it was "inoculated" rather than "natural" small-pox. Dr. Copeman adds:

> "In discussing the origin of the various lymph stocks at present in use, Messrs. Collins and Picton in their minority report make a point of the impossibility of employing at the present day what used to be known as the 'variolous test' as a proof of the efficacy or the reverse of any particular strain of lymph. In view, however, of my experiments with monkeys this criticism . . . falls to the ground; since if it is desired to apply the variolous test to any given lymph stock, all that is necessary is to vaccinate a monkey with a sample of the lymph in question, and subsequently to inoculate the animal with potent small-pox lymph after the lapse of such period from the first operation as may be thought desirable."

Dr. Copeman's researches upon the effect of glycerine in purifying and preserving vaccine lymph, date from 1891. Previous to this he had seen reason to think that the exuberant growth of what may be called extraneous organisms, might tend to check the development of the more important organism for which he was searching. He therefore set himself to find an agent which would check the growth of these extraneous or useless micro-organisms in lymph.

The use of glycerine as a diluent or preservative of lymph had long been known. What was not known was that by an intimate admixture of perfectly pure glycerine with lymph, and by storing the mixture for a considerable time under conditions which prevent the access of air and light, the foreign organisms in the lymph are gradually destroyed or so checked in their growth that they cease to multiply and come to an end. The proportion of glycerine required for this inhibitory influence is a large one—30 per cent., 40 per cent., or 50 per cent. for the different organisms. Dr. Copeman details experiments made by himself and Dr. Blaxall with lymph to which had been added, a month before using it, large quantities of virulent tubercle bacilli. No growth of the tubercle bacillus could be obtained, nor was any effect produced by repeated injections of this lymph into guinea-pigs, while from the same supply of tubercle culture material, not treated with glycerine, tuberculosis was in due course developed, at first locally and then generalised.

It must be borne in mind that an essential part of the process Dr. Copeman recommends is the length of time during which the organisms in the lymph are exposed to the influence of chemically pure glycerine, unaided by the vitalising influences of light and air.

Dr. Copeman gives photographs of a series of sub-cultures on nutrient agar-agar after twenty-four hours, then after one, two, three, four and six weeks respectively. The extraneous organisms progressively diminished till at the end of four weeks there were none, and after six weeks there were also none.

It is natural to ask if glycerine can in time, and under favouring conditions, entirely inhibit the growth of extraneous organisms, will not the essential vaccine organism presently share the same fate? Is glycerinated calf lymph sure to retain its activity for a sufficient length of time for all practical purposes? These questions scarcely admit at present of an absolute answer. Dr. Copeman believes the lymph from different calves varies very much in potency. He quotes facts which go to show that there is no reason to distrust the lymph treated as he recommends while stored in bulk.

> "A lymph which was collected and glycerinated on July 13, 1897, has since been used at intervals of from twenty-four to thirty-two weeks after glycerination, for the vaccination of children. During this period sixty-one children have been vaccinated with this lymph in five places each, with a mean insertion success of 98 per cent."

It must, however, be borne in mind that for the children thus vaccinated the lymph had not been kept in capillary tubes. It is necessary to wait for further experience before it can be taken as proved that glycerinated lymph can be kept in an active condition for any considerable time in such tubes. It would be interesting to know if lymph can be stored and distributed in fairly large bulk in such a way as to be available when wanted, even where, as on board ship, otherwise perfect conditions as to temperature, exclusion of light and air can be secured. A method by which enough perfectly pure lymph to vaccinate, say, a thousand people, in one series, could be carried through the tropics would be of great value, and there seems some ground for doubting if glycerinated calf lymph in capillary tubes would under such conditions be absolutely trustworthy. It would have for the round voyage to retain its potency for at least from four to six months.

Dr. Copeman's contribution to the study of the bacteriology of vaccination is of high value and interest.

A MODERN TYCHO.

Siddhánta-Darpana; a Treatise on Astronomy. By Mahámahopádhyáya Sámanta Sri Chandraṣékhara Sim̱ha. Edited with an introduction by Jogés Chandra Ráy, M.A., Professor of Physical Science, Cuttack College, Calcutta, 1897.

ANY one who reads the very interesting introduction of sixty-one pages that Prof. Ráy has attached to this Sanscrit work will regret very much his inability to fathom the work that follows. For therein is contained the results of the patient and industrious inquiry of one who, unaided by the accumulated knowledge of Western astronomers, resolutely set himself to solve the problem of celestial mechanics by the aid of such instruments as he could fashion himself, and where the time-honoured clepsydra supplied the place of the sidereal clock. The only assistance he seems to have had were the similar rough observations of Bháskara (born 1114) and some still older observers. Prof. Ráy compares the author very

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properly to Tycho. But we should imagine him to be a greater than Tycho, for without the same assistance, without the encouragement of kings and the applause of his fellows, he has advanced his favourite science quite as effectually as did the Danish astronomer. It is especially curious to notice that the system at which Chandrasékhara ultimately arrived, and the explanation he offers of it, bears a very considerable resemblance to that which Tycho taught. The author has never been able to convince himself that the earth turns on its axis, or that it goes round the sun; but to the planets he assigned heliocentric motion, much as Tycho did.

We get some notion of the success that attended the work, and of how much it is in one man's power to accomplish, if we examine the differences between the values he assigns to some of the constants of astronomy and those in use with ourselves. The error in the sidereal period of the sun is 206 seconds; of the moon, 1 second; Mercury, 79 seconds; Venus, about 2 minutes; Mars, 9 minutes; Jupiter, an hour; and Saturn, rather more than half a day. The accuracy with which he determined the inclination of the planets to the ecliptic is still more remarkable. Mercury offers the largest error, and that is only about two minutes. In the case of the Solar orbit the greatest equation to the centre is only 14 seconds in error. In the Lunar theory, the revolution of the node has been concluded with an error of about 5½ days, less than the thousandth part of the whole period; while he has independently detected and assigned very approximate values to the evection, the variation, and the annual equation.

The main object that Chandrasékhara had before him seems to have been to correct the calendar, and regulate the daily ritual of the Hindu religion. No two almanacs, Prof. Ráy tells us, agree; but any attempt to introduce the Nautical Almanac and its acknowledged accuracy would prove unsuccessful. The necessary corrections and unification must, to be acceptable, come from within and be the work of a Hindu, uninfluenced by foreign education. The work of Chandrasékhara has received the sanction of the honoured Rashis, and the adoption of the corrections which he has shown to be necessary will exert upon native society a beneficial influence, whose importance can be hardly overrated in a community where a correct almanac is an indispensable equipment of every household. We should like much to linger over Prof. Ráy's remarks on the subject of precession and his chronological deductions. These and many other points are discussed with great ability, though Prof. Ráy modestly disclaims any special astronomical capacity. The effect is to leave us at every page with a higher opinion of the author laboriously recording his observations on a palm-leaf, and unselfishly devoting his life to the services of his countrymen, who do not appreciate the nobility of the effort and the entirety of his devotion. We are in full sympathy with the editor when he writes thus of the author, of his privations and his star-gazing:

> "What has he done after all? asks the impatient critic. To him I would say—Is it not enough to find in this man a true lover of science, who, regardless of other people's unfavourable opinion of his work, their taunts and dissuasions, has devoted his whole life to the one pursuit of knowledge; who has shown the way to original research amidst difficulties serious enough to dishearten men in better circumstances; who has employed his time usefully, instead of frittering it away like the usual run of men of his rank, on a work which guides the daily routine of millions of his countrymen."

W. E. P.

OUR BOOK SHELF.

Photography: its History, Processes, Apparatus, and Materials. By A. Brothers, F.R.A.S. Second Edition. Pp. xviii + 367. (London: C. Griffin and Co., Ltd., 1899.)

MR. BROTHERS, of Manchester, has been known for so many years in connection with photography and allied subjects, that his personal experiences have much value for the student. The time is gradually approaching when the history of the early developments of photography will be completed, because it will be impossible to add to our recorded knowledge of them; meanwhile we welcome every addition. Mr. Brothers describes the first experiments in the use of magnesium as an illuminant for photographic purposes, and how he found that the wire burned better when it was flattened into ribbon by passing it between rollers. The first photograph taken underground was by Mr. Brothers, and he gives a reproduction of it. It was produced in 1864 in the Blue John Mine in Derbyshire, by the aid of burning magnesium. In the following year Prof. Piazzi Smyth used the same illuminant in photographing the chamber in the interior of the Great Pyramid. Being in doubt as to who was the first to use sodium thiosulphate as a fixing reagent, Mr. Brothers, in 1866, wrote to Sir John Herschel, and received from him a long letter on the subject, which is printed in full in the work before us. In it Sir John gives quotations from his papers on "hyposulphurous acid and its compounds," published in the *Edinburgh Philosophical Journal* of 1819, and also extracts from his own laboratory note-book of January 1839, which appear to establish his claim to being the first to use the thiosulphates in photography. The description of Sir John's attempts to imitate the photographic successes of Daguerre, of which at that time there were only very vague reports as the process was not published until later in the year, are very interesting.

Although the volume is called a "Manual of Photography," it is hardly what is commonly understood by this term. After introductory matter, which is chiefly a consideration of chemistry, optics, and artificial light, as applied in photography, there follow sections titled "Processes," "Apparatus," "Materials used in photography," "Applications of photography," and "Practical hints." In each section the numerous headings are alphabetically arranged, their descriptions extending from two or three lines to, occasionally, several pages in length. The space allotted to each subject is not proportional to its demands. While more than eight pages are devoted to the stereoscope, less than three are given to carbon printing, and for details of this most important of processes the student is referred to the guide issued by the Autotype Company! This being a second edition, much new matter has been added, Radiography, the "krōmoscōpe," the new developers, and some of the newer lenses are described, the last chiefly by quotations from the makers' price lists. The greatest advance in photographic optics since Petzval calculated the portrait lens that bears his name, is practically ignored. Astigmatism is referred to, in a dozen lines or so, as "a defect most general in portrait lenses" that "has to be reduced to a minimum by the use of a diaphragm." It is worth noting that at both pages

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